# Limiting white pine weevil attacks by side and overstory shade in the Prince George Forest Region

S.P. TAYLOR

BRITISH COLUMBIA FOREST SERVICE, PRINCE GEORGE, CANADA V2L 3H9

and R. D. COZENS

BRITISH COLUMBIA FOREST SERVICE, VICTORIA, CANADA V8W 3E7

## ABSTRACT

A study was initiated in 1985 to measure the effects of side and overstory shade on attack by white pine weevil and on annual growth in interior white spruce. The study was undertaken in the Prince George Forest Region where the weevil causes extensive damage to plantations of interior white spruce. Annual attack rates decreased significantly with increased brush cover. The treatment with side shade was achieved using narrow strip cuts running east and west. Side and overstory shade also reduced annual growth. Results indicate that up to 6% reductions in annual attack rates could be expected for at least 5 years following treatment but that differences in attack rates between treatments took at least three years to appear.

## INTRODUCTION

Young trees of interior white spruce (*Picea glauca* (Moench) Voss *engelmannii* Parry ex Engelm.) are subject to severe damage by the white pine weevil (*Pissodes strobi* (Peck)) in the Prince George Forest Region (Taylor *et al.* 1991). This damage results in the formation of stem defects such as crooks and forks (Alfaro 1989), which reduce the merchantability of the tree. Growth loss also occurs since the leader is killed through girdling by the larvae of the weevil.

Effects of side or overstory shade on damage levels and weevil behaviour have been reported for interior white spruce, Sitka spruce (*Picea sitchensis* (Bong.) Carr.) and eastern white pine (*Pinus strobus* L.). Shade has direct or indirect negative effects on weevil feeding, oviposition activity and brood development (McMullen 1976, Sullivan 1959), on the weevil's visual response to the leader silhouettes of the host (VanderSar and Borden 1977), and on survival of overwintering adults (Harman and Kulman 1969, Droska 1982). Shading also reduces the diameter and length of the leader to less than the size preferred by the attacking weevils (Harman and Kulman 1969, Taylor *et al.* 1991) and improves recovery of damaged trees (Alfaro and Omule 1990).

The purpose of this study was to quantify the effects of side and overstory shade both on weevil attacks and the annual growth of the spruce.

## METHODS

The study was conducted in the Prince George Forest Region in mesic plantations located in the willow variant of the wet cool sub-boreal spruce subzone (see Pojar *et al.* 1987 for details of this classification system). Three interior white spruce plantations, 50 kilometers east of Prince George, were selected (Fig. 1) to establish this trial after a random walk through them indicated an active weevil population. These plantations had been clearcut in 1969, site prepared with a broadcast burn in 1970 and planted in 1971 with 2+1 bareroot spruce seedlings (grown for two years in the nursery greenhouse and for one year in outside transplant beds).

Three treatment plots were established in each plantation (Fig. 1 and 2) as follows:

- the overstory shade were untreated controls with an intact deciduous overstory that was relatively continuous. The overstory shade trees that overtopped the spruce were: trembling aspen (*Populus tremuloides* Mich), paper birch (*Betula papyrifera* Marsh), willow species (*Salix* spp.) and alder (*Alnus crispa* spp. *sinuata* (Regal) Hult);
- the no shade treatment had all of the deciduous overstory removed at one time; and

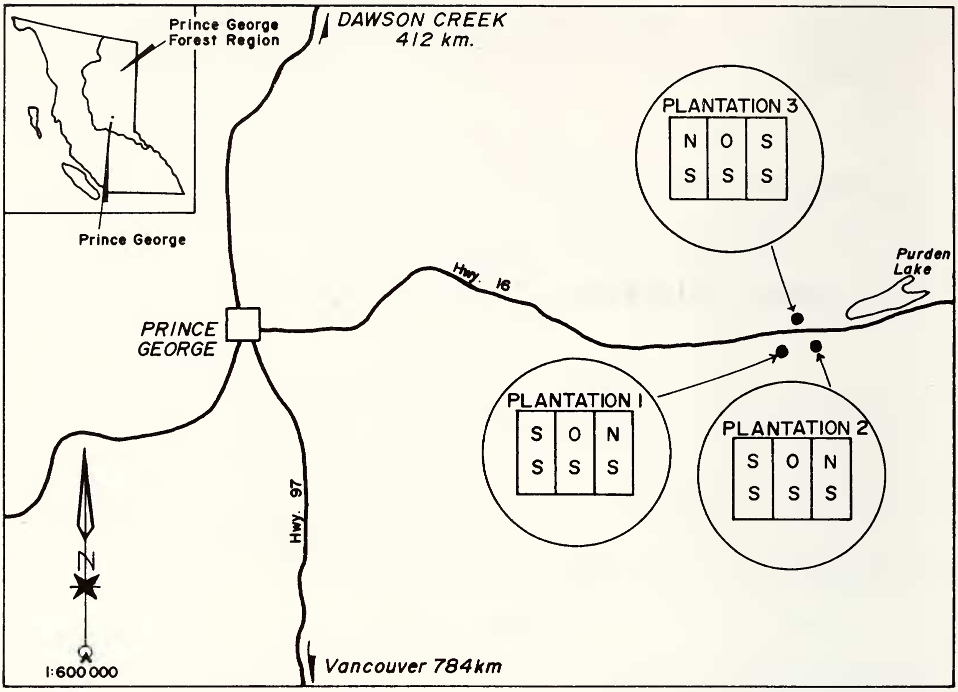


FIGURE 1. Location and design of the plots in the three study plantations. (Treatments for plots: SS = side shade, OS = overstory shade, and NS = no shade)

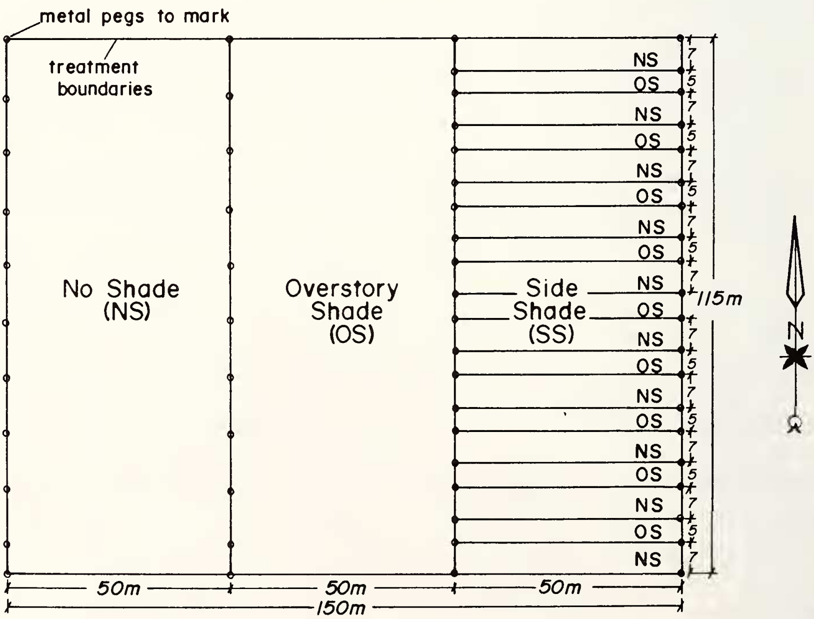


FIGURE 2. The plot design for the project, replicated on each of three plantations.

- the side shade treatment consisted of alternate strips with brush removed (no shade) and unbrushed strips (overstory shade), so that the crop trees in the debrushed strips were in partial or side shade from the unbrushed strips.

Strips in the side shade treatment were run in an east-west direction to provide shading to the exposed spruce trees when the sun angle was at its maximum. A maximum angle of 58.5° was calculated to occur at noon on the 21st of June at the study sites (Anon. 1965). The sun angle one hour before and after the noon maximum was determined to be 55°. This lower angle was used for the calculations of required strip width.

Plots were laid out and cleared mechanically of brush in November of 1985. A stem map of the plots were completed in April 1986 and all spruce trees were permanently identified with numbered metal tags. The past occurrence of weevil attacks was estimated to provide a history of weevil activity within the stand, and annual weevil attacks with leader and diameter growth were periodically recorded.

A randomized complete block design was used in this experiment with three blocks (plantations) and three silvicultural treatments (plots) within each block. The annual growth and weevil rate attack data were subjected to analysis of variance in order to assess potential treatment effects. Data analysis for the weevil attacks was conducted on the sample means for each plot, but data analysis for height increment was based on the individual observations within each plot.

Analysis of variance was conducted for annual height growth using the following linear model:

$$Yijk = u + Pi + Tj + PTij + Eijk$$

where
u – grand mean
Pi – ith plot effect
Tj – jth treatment effect
PTij – block by treatment interaction
Eijk – residual error

The least square solution was used to compute the sum of squares and significance test by SAS GLM procedures (SAS 1985, Searle 1987).

Preliminary analysis showed that the weevil attack data were not distributed normally. Thus, analysis of variance was not appropriate. As these data were binomially distributed a loglinear model was used for analysis of variance (Bishop, Fienberg and Holland 1975). The SAS CATMOD Model (SAS 1985) was used to test the differences in weevil attack on the three treatments. Then the Chi-Square Test was used to test for differences between means of attack rates as this was discrete data and the Duncan Multiple Test was used on the height increments, a continuous variable.

## RESULTS

The annual attack rates for 1993 averaged 21.3%, 14.8% and 15.1% for the no shade, side shade and overstory shade treatments respectively (Fig. 3). Significant treatment effects, at the 1% level (Table 1), appeared in 1989 and persisted for the 1990, 1991 and 1993 remeasurement periods. However, no significant differences were found before 1989. No measurements were taken in 1992. The multiple contrasts indicated that all comparisons between no shade versus overstory shade, and between no shade versus side shade were significant from 1989 to 1993 (Table 1).

It took three full growing seasons before differences in attack rates between treatments started to show. The maximum difference between the no shade and overstory shade plots was 6% in 1993. Table 1 also indicates that there were interactions at the block level possibly due to the site. These interactions vindicate the decision to use a randomized complete block design.

The density of the trees was 951, 1151 and 791 stems per hectare for plantations 1, 2 and 3 respectively. The mean height in 1991, in all plots, was 4.4 ± 1.4 m (S.D.) and mean DBH was 6.2 cm (± 2.6 cm).

Analysis of variance indicates that there were significant treatment effects at the 1% proba-

**Table 1**

Effect of three silvicultural treatments (Overstory Shade, Side Shade, and No Shade) on percentage of weevil attacks and results of analysis of variance by category model method.

| Year | 1987 | 1988 | 1989 | 1990 | 1991 | 1993 |
|---|---|---|---|---|---|---|
| *Treatment* | *Average percentage of weevil attacks*[a] | | | | | |
| Overstory Shade | 1.59a | 1.22a | 2.37a | 2.70a | 4.56a | 15.10a |
| Side Shade | 1.16a | 1.21a | 3.13a | 2.96a | 5.83a | 14.75a |
| No Shade | 2.20a | 1.53a | 5.39b | 5.70b | 9.16b | 21.30b |
| *Sources of variation* | *Probability levels*[b] | | | | | |
| Treatment | 0.829 | 0.789 | 0.002** | 0.004** | 0.001** | 0.013** |
| ($\chi^2_{2,4}$) | (0.37) | (0.45) | (12.51) | (11.13) | (17.85) | (8.69) |
| Block | 0.001** | 0.002** | 0.001** | 0.001** | 0.001** | 0.346 |
| ($\chi^2_{2,4}$) | (24.49) | (12.51) | (35.25) | (38.79) | (27.47) | (0.89) |

a Means within columns, followed by the same letter are not significantly different ($p$=0.05) according to $\chi^2$ pairwise contrasts of categorical model.

b ($\chi^2_{2,4}$) is a Chi-square value under null hypothesis.

**Significant difference at 1% level.

**Table 2**

Effect of three silvicultural treatments (Overstory Shade, Side Shade and No Shade) on annual height increment (mean ± standard error) and results of analysis of variance.

| Year | 1986 | 1987 | 1990 | 1991 |
|---|---|---|---|---|
| *Treatment* | *Average annual height increment*[a] *(cm)* | | | |
| Overstory Shade | 22.4±0.5a | 27.9±0.6a | 36.1±0.4a | 42.8±0.4a |
| Side Shade | 21.9±0.4a | 25.9±0.5b | 38.0±0.4b | 44.4±0.5b |
| No Shade | 18.5±0.3b | 22.0±0.4c | 37.6±0.5b | 45.3±0.4b |

a Means within columns, followed by the same letter are not significantly different at ($p$=0.05) level according to Duncan multiple comparison.

bility level on all height increments (Table 2). The tests for multiple comparisons accentuate these differences as the order of the significant relationship between the no shade and overstory shade regimes in 1986 are reversed for the 1991 measurements (Table 2). It is interesting to note that height increment also took about three growing seasons before differences started to appear. There are significant differences between plots, but no significant interaction effect between plot and treatment.

## DISCUSSION

The reduction in weevil damage and spruce growth rates reported in this study are similar to those reported in Stiell and Berry (1985) for white pine, McLean (1989) for Sitka spruce and Taylor *et al.* (unpublished observations) for interior white spruce. The fact that differences in attack rates between treatments varied only between 1 to 6% indicates that measures to modify broadcast herbicide treatments, as suggested in Taylor *et al.* (unpublished observations), will not be worthwhile until current attack rates exceed at least 15% to 20%. If the attack rates had been at this level when the experiment started, larger differences between treatments may have been noticed. Nonetheless, a side shade regime should significantly reduce the levels of weevil attacks in areas of high weevil hazard.

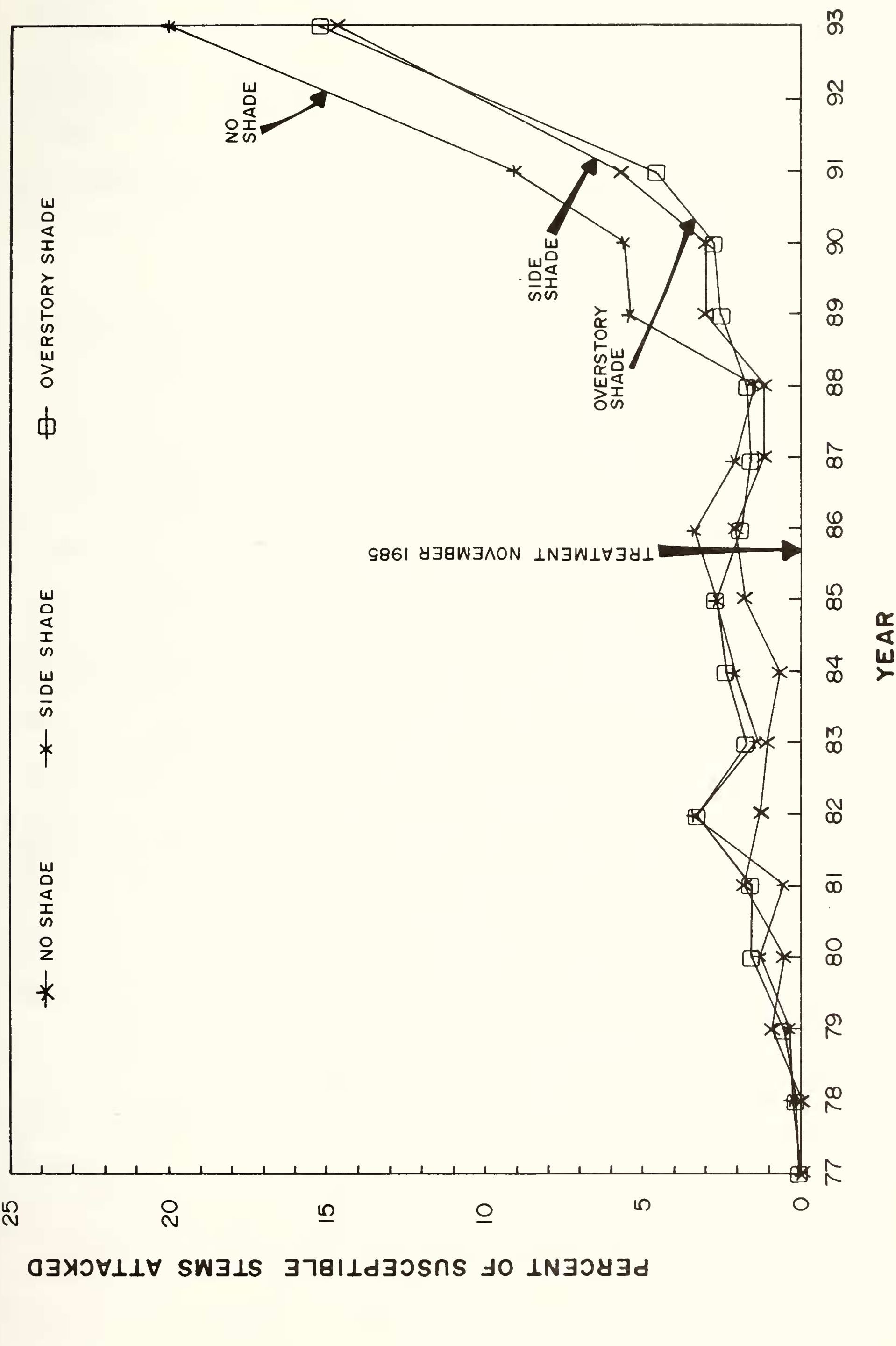


FIGURE 3. A comparison of current attack rates between the three treatment regimes.

The weevil seems to need at least three full growing seasons to manifest its response with increased attack rates at a stand level. A partial explanation for this may be either that initial attack rates were relatively low when the project started or that the stand level differences in shade levels between treatments were minor. A similar delayed response has been noticed on permanent weevil plots in the Southern part of the Region.

Increased height increment with decreased shade levels is a well documented phenomenon and helps to support the contention found in Taylor *et al.* (unpublished observations) that a trade-off exists between reduced weevil attack and decreased spruce growth rates. The exact nature of this trade-off must be left for future study.

The close relationship observed here between weevil attack rate and annual growth has been commonly accepted for white pine and Sitka spruce for a long time (Wood and McMullen 1983; Kline and Mitchell 1979; and VanderSar and Borden 1977).

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